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# Solar collector

## Description

The present invention relates to a solar collecting module characterized by the terms in claim 1.

Solar collectors of the above type use a parabolic shaped reflecting surface to collect and focus sunlight onto a focal line. The reflecting surface is moved along its horizontal axis to follow the movement of the sun during the day.

These solar trough collectors have proved themselves over many years and are manufactured with different mirror support structures.

Modern solar collectors are up to 100 meters long and are approximately 6 meters wide.
They are driven using one or more electric motors.
As is evident from the dimensions of these collectors and the fact that they stand exposed to the weather they are subject to high wind forces. These wind forces place high demands on the collecting modules in relation to the stability of the mirror support structures.
These forces are especially high in relation to the twisting or torsional rigidity of the structure. The reflecting and concentrating properties of the collectors are adversely affected by even small deformation and this affects the efficiency of the installation.
In order to provide enough resistance to these torsional deformation forces reticular tube structures are used to support the parabolic shaped mirrors. This uncoupling of support structure and pre-formed reflectors results in an extremely complex overall structure.

An example is the solar collector DE-A-198 01 078 which uses such a reticular tube structure to support the reflector surface. The support structure is connected to a carrier tube, which provides the torsional rigidity. The reticular support, however, does not contribute to the torsional strength, which means that these constructions are still prone to torsional deformation.

Another example is the parabolic trough concentrator DE-A-197 44 767 that likewise uses a reticular support structure.

Diagonal tubes connected to the individual support arms provide the torsional rigidity. This type of construction is suitable solely for short collector modules as the torsional rigidity is not optimal.

DE-A-199 52 276 presents a parabolic trough collector in which swiveling support arms are arranged on a central axis. Here also the torsional rigidity originates only from the central axis tube. The arms themselves do not contribute to the torsional strength.

WO-A-02 103 256 demonstrates a parabolic solar collector which has a central tube onto which side arms are mounted. This type of reflector is indeed relatively resistant to bending but has almost no torsional rigidity.

The present invention is based on the task of building a solar collector, which provides torsional rigidity in a simple construction.

This task is resolved by a solar collector module having the features of claim 1.

In the present invention forming ribs are surrounded by an outer skin layer. Together these form an enclosed box construction, which possesses very high torsional strength. In addition, the form ribs are also parabolic shaped on their concave edge so that the reflector material takes on the parabolic trough shape when impressed upon the reflector. This means that the reflecting surface material need not be rigid. Pre-formed parabolic mirrors, which are relatively expensive, are not necessary. Instead, the material can be pliable.
This pliable reflector material can, for example, be delivered on a roll and then cut to the required size on site. Transport costs are, in this way, considerably reduced and the reflector surface material itself is also considerably cheaper than pre-formed parabolic mirrors.

The present invention has the advantage of high torsion strength and that, not only pre-formed parabolic mirrors, but also pliable reflector material can be utilized because the parabolic trough shape is impressed on the outer skin in the concave area of the form ribs.

A further embodiment provides that the form ribs demonstrate a sickle shape. Because of this sickle shape the whole support structure with its outer skin has, essentially the form of a supporting wing. This is, for example, familiar in aircraft or ship construction and possesses high rigidity in regard to bending and torsion factors.

In order to give the form ribs the desired shape in a simple manner they are manufactured using a folding or rippling process so that a concave lateral edge results that is essentially parabolic shaped. At the same time the edge opposite the parabolic edge can be arched.

Onto this closed, torsion rigid support construction, formed by the form ribs and the outer skin the pliable reflector material is applied so that it adopts the parabolic shape.

Preferably a trapezoidal metal sheet is laid onto the outer skin, which lies on the parabolic lateral edge. This sheet has grooves running lengthways along the curved trough shaped collector onto which the reflector material is laid. This has the advantage that the supporting surfaces of the reflector material, formed by the grooves in the trapezoidal sheet, are free from obstructions, for example, screw or rivet heads and that the grooves form parallel running, strip surfaces which support the shape of the reflector material. Thereby, too, compensation for materials with different heat expansion coefficients, for example, glass reflector materials and metal outer skin or support structure is achieved.

The grooves of the trapezoidal metal sheet form channels that are apt to be sealed at their lateral ends. These kind of closed channels have the advantage that they can be evacuated so that, when the pliable reflector surface material is placed onto the support surfaces of the grooves with a layer of adhesive between, the channels of the grooves can be evacuated and the reflector material is held in place. This can be continued until the adhesive layer has sufficiently hardened. By this means, special clamping systems can be spared. Another possible method for pressing the pliable reflector material in place is that, after laying the reflector in place, the trough is closed at the lateral ends and filled with water. Through the water pressure the reflector material is pressed onto the grooves while the adhesive hardens.

In an embodiment, the trapezoidal metal sheet is fixed, together with the outer skin, to the form ribs using, for example, screws or rivets. In this way, a separate riveting or screwing process is avoided because the outer skin lies between the form ribs and the grooves of the trapezoidal sheet and is held in place by the fastening of the trapezoidal sheet to the form ribs.

As already mentioned, it is advantageous to glue the reflector material to the grooves of the trapezoidal sheet. In this way, small deformations in the surface of the reflector material are avoided. Apart from this, different materials, as well as glass, can easily be fixed to the trapezoidal sheet.

In this way, the reflector material used in the present invention can be a metal or synthetic foil or a thin glass layer with a thickness of, for example, 1mm. The foil material having a reflecting upper surface and the glass a reflecting surface on one or both sides.

These thin materials have the special advantage that a second or more layers can be added to them. In this way repair is considerably simplified. Due to environmental effects the reflector surfaces become gradually "blind" in that the reflecting properties are adversely affected. They must then be either exchanged or the mirror surface renewed. Whereas the present invention allows for new layers of reflecting material to be added.

Along the focal line of the collector provision is made for a receiving tube, which is supported by support arms. These are attached to the form ribs and/or the upper surface of the reflector (16).
This simple structure contributes to an inexpensive construction of the present invention.

Further advantages, characteristics and details of the present invention are contained in the following description in which especially preferred embodiments are represented in detail with reference to the drawings.

The characteristics represented in the drawings as well as those mentioned in the description and / or the claims can relate individually or in any combination to the present invention.

The drawings show:

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| Fig.1 | A perspective representation of a reflector module. |
| Fig.2 | The support structure of a reflector module. |
| Fig.3 | Lateral view of a form rib in the direction of arrow 111 in Fig.2. |
| Fig.4 | A blank cutting for form ribs. |
| Fig.5a to 5c | Details of production steps in the manufacture of a form rib. |
| Fig.6 | An alternative drive for a reflector module installed on a level base. |

Fig.1 shows a reflector module (10), a plurality of which constitute a solar collector plant.
This reflector module (10) is fastened to a support structure (not shown) and is arranged so that the incident sun's rays strike the concave area (12) and from there are reflected onto a receiving tube (14) (see Fig. 3). For this the concave area (12) is formed from a parabolic shaped reflector.

The reflector module (10), as schematically represented in Fig.2, consists of a plurality of form ribs (18), which lay parallel to each other. The form ribs (18) are clad on their concave edge (12) and their convex edge (20) with an outer skin (22) as represented in Fig.1. The outer skin (22) is fixed to the form ribs (18) by means of screws, rivets or some other means. In this manner the form ribs (18) and the outer skin (22) form an enclosed support structure.

In Fig.3 rivets are schematically represented by means of which the form ribs (18) and the lower section (26) of the outer skin are fastened.

An upper section (28) of the outer skin (22) is laid onto the concave edges (12) of the form ribs (18) and onto this upper section (28) of the outer skin (22) a trapezoidal metal sheet (30) is laid. The lower bridges (32) of the trapezoidal sheet (30) together with the interposed upper section (28) of the outer skin (22) are then riveted to the form ribs (18). The upper bridges (36) of the trapezoidal sheet (30) now form the laying surface for a reflector material (38), which is pliable and rests on the upper bridges (36).

In this way the reflector material (38) adopts the characteristic shape of the concave surface of the trapezoidal sheet (30). This shape is the desired parabolic form, which allows the incident sun's rays to be directed onto the receiving tube (14). The reflector material (38), which can consist of a reflecting metal or synthetic foil or a layer of thin glass mirror having a thickness of, for example, 1mm is then glued to the upper bridges (36).

Fig.3 shows, in addition, a support arm (40) apt to carry the receiving tube (14). These arms are fastened by rivets or some other means to the reflector (16) together with the upper bridges (36) of the trapezoidal sheet (30) and or with the underlying form ribs (18).

Fig.4 shows a metal strip (ref. No 42) with a width of 1200mm out of which alternating blanks (44) are cut each blank being 6000mm long. These blanks (44) or (46) as shown in Fig. 5a are further processed with a metal folding machine (not shown) in that they are bent to form the concave area (12) contained in the lateral edge (48). This is achieved by rippling (50) or folding. The section thus formed still has an essentially angular outer form that is chamfered in the next production stage by pressing or folding. During this production stage the lateral edge (48) is cut and or flanged so that, after laying the outer skin (22), the trapezoidal sheet (30) and the reflector material (38) onto the upper section (26), all have the desired parabolic shape.

In addition recesses (52) are introduced through which pipes for liquids and electric power cables can run inside the reflector module (10). The rivets are fastened through the flanged edges.

Altogether it can be see that the present invention comprising a plurality of reflector modules (10) possesses the considerable advantage that each reflector module (10) has the required torsion rigidity and that pliable reflector material (38) can be used onto which the parabolic shape is impressed by the trapezoidal sheet (30) and the form ribs (18). It is therefore not necessary to use expensive pre-formed rigid mirrors. Relatively inexpensive foil materials can be utilized or thin glass mirror, which are also less expensive.

The bonding bridges (54) connecting the upper bridges (36) and the lower bridges (32) balance different heat expansion coefficients between the reflector material (38) and the outer skin (22) without problem. In this way heat stress factors do not build up.

In an embodiment represented in Fig. 6 the reflector modules (10) lie on a level base and can be swiveled by means of a suitable drive. The lower section (26) of the outer skin (22) is provided with a cogging, which engages, with another cogging or a pair of cogwheels mounted on the base. This type of fixed reflector module (1) is even more resistant to buckling than hanging modules. They are also less exposed to the wind.